EXTRACTION OF ESSENTIAL OILS FROM GINGER RHIZOME USING STEAM DISTILLATION METHOD

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A thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Chemical Engineering

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NOVEMBER 2006

I declare that this thesis entitled "*Extraction of Essential Oils from Ginger Rhizome Using Steam Distillation Method*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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DEDICATION

Special dedication to my family members that always inspire, love and stand besides me, my supervisor, my beloved friends especially the one who always help me, my fellow colleagues,
and all faculty members

For all your love, care, support, and believe in me. Thank you so much.

ACKNOWLEDGEMENT

Praise is to God for His help and guidance that finally I'll able to complete this final year project as one of my requirement to complete my study.

First and foremost I would like to extend my deepest gratitude to all the parties involved in this research. First of all, a special thank to my supervisor Mr. Ahmad Ziad bin Sulaiman for his willingness in overseeing the progress of my research work from its initial phases till the completion of it. I do believe that all his advices and comments are for the benefit of producing the best research work.

Secondly, I would like to extend my words of appreciation to all staff in the lab especially all teaching engineers for their guidance and valuable advice during the experiment of this research. I do believe that all their advice, commitments and comments are for the benefit.

To all my friends especially my best friend and all my course mates, thank you for believing in me and helping me to go through the difficult time. The experiences and knowledge I gained throughout the process of completing this final project would prove invaluable to better equip me for the challenges which lie ahead. Last but definitely not least to my family members, I can never thank you enough for your love, and for supporting me throughout my studies in University College of Engineering & Technology Malaysia (KUKTEM).

ABSTRACT

Essential oils are highly concentrated essences of aromatic plants. It can be extracted using a variety of methods such as steam distillation and solvent extraction. Essential oils have a very high commercial value due to its therapeutic properties. It is widely used in aromatherapy, medicine and as well as flavoring food and drink industries. To get the approximately pure essential oil from raw material, conventional extraction technique like steam distillation is used. Steam distillation is unlikely solvent extraction. This is because steam distillation is to produce essential oils but solvent extraction will produce oleoresin. Pure essential oil can be derived from a part of ginger plant that is the ginger rhizome by using steam distillation method. The extraction of the ginger essential oils began when steam contact to the ginger in the extraction tank. The steam carried out the essential oils from the ginger out of the rhizome and go through the condenser. Then, the steam with the essential oils will be condensed into liquid phase and will be collected in the beaker. Lastly, the two liquids will be separated. To get high quality and quality of essential oils, the fire from burner that burned the tank and produce steam in the tank must be well controlled. Apart from being effective, this study might as well discover potential savings in its operational cost and also environmental friendly.

ABSTRAK

Pati minyak adalah sangat berkepekatan tinggi daripada tumbuh-tumbuhan aromatik. Ia boleh diekstrak dengan menggunakan pelbagai kaedah seperti penyulingan wap air dan pengekstrakan dengan bahan pelarut. Pati minyak mempunyai suatu nilai komersial yang tinggi berdasarkan sifat-sifatnya yang berunsurkan nilai pengubatan. Ia digunakan dengan meluas dalam aromaterapi, perubatan dan termasuk juga industri memperisakan makanan dan minuman. Untuk mendapatkan pati minyak yang hampir-hampir tulen daripada bahan mentah, teknik yang lazim digunakan adalah seperti penyulingan wap air. Penyulingan wap air tidak seperti pengekstrakan dengan bahan pelarut. Ini disebabkan penyulingan wap air adalah untuk menghasilkan pati minyak tetapi pengekstrakan dengan bahan pelarut akan menghasilkan oleoresin. Pati minyak tulen boleh didapati daripada sebahagian daripada tumbuh-tumbuhan halia iaitu akar halia dengan menggunakan kaedah penyulingan wap air. Pengekstrakan pati minyak halia bermula apabila wap air menyentuh kepada halia di dalam tangki pengekstrakan. Wap air membawa keluar pati minyak daripada akar dan pergi melalui kondenser. Selepas itu, wap air dengan pati minyak akan diwap cairkan ke fasa cecair dan akan dikumpul di dalam bikar. Akhir sekali, kedua-dua cecair itu akan dipisahkan. Untuk mendapatkan pati minyak yang berkualiti dan berkuantiti tinggi, api daripada dapur gas yang menghasilkan wap air mesti dikawal dengan baik. Selain efektif, kajian ini juga ekonomikal melalui penjimatan kos operasinya dan ia juga adalah mesra alam.

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LIST OF ABBREVIATIONS

KUKTEM	=	Kolej Universiti Kejuruteraan dan Teknologi Malaysia
FID	=	Flame Ionization Detector
GC	=	Gas Chromatography
HPLC	=	High Performance Liquid Chromatography
WCOT	=	Wall-coated open tubular
SCOT	=	Support-coated open tubular
ML	=	Moisture lost

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CHAPTER 1

INTRODUCTION

1.1 Overview of Ginger

Ginger, a very useful herb plant, is said to be originated from India, China and Java, yet is also native to Africa and the West Indies. It is grown throughout the tropical areas of the world and also commonly found in South East Asia especially in Indo-Malaysia. The main producer of ginger is Jamaica. Ginger is scientifically named as *Zingiber officinale Roscoe*. On 1807, an English botanist, William Roscoe (1753-1831) named the plant as *Zingiber officinale* in his publication.

1.2 Physical Properties of Ginger

The name *Zingiber* is consequent from the Sanskrit word for “horn- shaped” and refers to the protuberances on the rhizome. *Zingiber officinale* belongs to the botanical family of the *Zingiberaceae.* Ginger is a perennial plant with upright reddish stem, looking like leaves, and grows from one to three or four feet in height. The stem is surrounded by the leaves. It shoots up a stem with narrow spear-shaped leaves, as well as white or yellow flowers growing directly from the root.

1.3 Usage of Ginger

Ginger has been used for a few purposes since very early times. It is used as a medicine since many years ago. It is also widely used as a cooking herb, condiment, spice and home remedy for a long time ago.

In medicinal uses, the ginger root is an effective treatment for nausea caused by motion sickness or other sickness. This kind of medical usage was found by earlier researchers, D.B. Mourey and D.E. Clayson. For morning sickness, it is not recommended to take the ginger root because morning sickness commonly associated with pregnancy. Ginger extract also has long been used in traditional medical practices to decrease inflammation.

Today, many herbalists use ginger to help treat health problems associated with inflammation, such as arthritis, bronchitis, and ulcerative colitis. To shorten the story, ginger oil is used in the treatment of fractures, rheumatism, arthritis, bruising, carbuncles, nausea, hangovers, travel and sea sickness, colds and flu, catarrh, congestion, coughs, sinusitis, sores on the skin, sore throat, diarrhea, colic, cramps, chills and fever. Beside that, ginger oil is used for cooking, as a flavoring for cookies, biscuits and cake, and it is the main flavor in ginger ale, a sweet, carbonated, non-alcoholic beverage.

1.4 Usual Methods of Obtaining Ginger Essential Oil

In *Zingiber officinale Roscoe*, there are many constituents such as acids, shoagaols, gingerol, essential oils, fiber, amino acids and minerals. There are two ways of extraction, that is using steam distillation and solvent extraction. In order to get oleoresin, solvent extraction technique is used but to obtain essential oil, steam distillation technique is used.

Steam distillation method is used for temperature sensitive material like natural aromatic compounds. For this method, there is no solvent is used to extract the material but pure water is the main component to do it.

1.5 Steam Distillation

In this research, the separation process that has been chosen is steam distillation. Steam distillation is one of the separation processes that used solid-liquid extraction theory. Liquid will be used to extract the solid. It means the essential oil will be removed from its raw material.

The extractor for this process will have three main parts. First, the steam will be supplied into the vessel. The steam will contact to the raw material and force the essential oils out of its raw material. Second, a condenser will be used to change the mixture of vapors to be two separated layer of water and essential oil. This two separated mixture occurs because of the different in density. Lastly, the mixture of water and essential oil will be collected in a vessel.

Steam distillation is most used to produce many types of essential oil such as from ginger. The process is cheaper than other extraction processes. It will not use any solvent and can make it safer than other processes.

1.6 Problem Statement

Generally, there are a few problems that arise in ginger extraction. There are many types of extraction. The extraction can be conducted with or without solvent. But, to get the essential oil, extraction through steam distillation is the most used method.

Without any solvent, pure water is used at its boiling point as steam to extract the essential oil from ginger. The steam is forced over the ginger. The steam will help to release the aromatic molecules from the ginger. The molecules of these volatile oils then escape from the ginger plant and evaporate into the hot steam. The temperature of the steam must be carefully controlled. It is because to control the ginger from burning and lost its purity.

Most of the essential oils have medicinal properties and it had been used since thousand years ago. Today, the essential oil from the ginger is widely used and the most important is that the ginger oil is used in medical field for a few sicknesses.

Nowadays, essential oil of ginger is highly needed because of the usage for medical field. The pungent components in ginger are proven beneficial in treating health problems. Many researches have been performed to discover the usage of ginger in various fields, especially in the medicinal field.

In other hand, the ginger flavor is containing aromatic and pungent component which is important in the flavor industries but recovery of both components at the same time has not been possible by conventional separation processes. To recover both components, steam distillation unit must be designed.

This equipment will be very useful for KUKTEM. KUKTEM will be one of the institutions that can produce essential oil using steam distillation method. The highly demand of the essential oil make KUKTEM take the chance to develop the technology.

1.7 Objective

The main objective of this study is to produce essential oils from the ginger rhizome using steam distillation method.

1.8 Research Scope

This research is an experimental study of steam distillation method using ginger as raw material. In order to realize the objective, three scopes have been identified. The scopes are:

i. To know the effect of extraction time to the yield of ginger essential oils.
   The experiment will be done for eight hours. After every one hour, the ginger essential oils will be collected.
ii. To study the effect of surface area of the ginger to get higher yield.
   Two different size of ginger rhizome will be prepared which are sliced and grinded to use for the experiments.
iii. To analyze the product using GC.
   This study is focus on using the gas chromatography (GC) to analyze the essential oil from raw material.

1.9 Contribution of The Study

The steam distillation equipment is expected to produce the best quality of essential oil from the ginger. There are some expected results from this research:

i. The equipment for steam distillation will be one of the most efficient and effective to produce essential oil.

ii. Application of advanced technology in ginger extracting process.

iii. Potential savings in the operational cost.

iv. The environmental friendly experiment will be conducted.

CHAPTER 2

LITERATURE REVIEW

2.1 Separation Processes

Many chemical process materials and biological substances occur as mixtures of different components in the gas, liquid, or solid phase. In order to separate or remove one or more of the components from its original mixture, it must be contacted with another phase. The two phases are brought into more or less intimate contact with each other so that a solute or solutes can diffuse from one to the other. The two bulk phases are usually only somewhat miscible in each other. During the contact of the two phases the components of the original mixture redistribute themselves between the two phases. The phases are then separated by simple physical methods. By choosing the proper conditions and phases, one phase is enriched while the other is depleted in one or more components.

Separation process is defined as a process that transforms a mixture of substances into two or more compositionally-distinct products. It is also defined as any set of operations that separate of two or more components into two or more products that differ in composition (Noble & Terry, 2004). Separation is attained by exploiting the differences between chemical and physical properties of the substances through the use of a separating agent (mass or energy). There are a few examples of separation process:

i. Absorption

When the two contacting phases are a gas and liquid, this operation is called absorption. A solute or several solutes are absorbed from the gas into the liquid phase in absorption.

ii. Distillation

In the distillation process, a volatile vapor phase and a liquid phase that vaporizes are involved.

iii. Liquid-liquid extraction

When the two phases are liquids, where a solute or solutes are removed from one liquid phase to another liquid phase, the process is called liquid-liquid extraction.

iv. Leaching

If a fluid is being used to extract a solute from a solid, the process is called leaching. Sometimes this process is also called extraction.

v. Membrane processing

Separation of molecules by the use of membranes is a relatively new separation process and is becoming more important. The relatively thin, solid membrane controls the rate of movement of molecules between two phases.

vi. Crystallization

Solute components soluble in a solution can be removed from a solution by adjusting the conditions, such as temperature or concentration, so that the solubility of one or more of the components is exceeded and they crystallize out a solid phase.

vii. Adsorption

In an adsorption process, one or more components of a liquid or gas stream are adsorbed on the surface or in the pores of a solid adsorbent and a separation are obtained.

viii. Ion exchange

In an ion exchange process, certain ions are removed by an ion-exchange solid. This separation process closely resembles adsorption.

Separation process is done for its own function. There are three primary functions of separation processes:

i. Purification

   It is used to remove undesired components in a feed mixture from the desired species.

ii. Concentration

   It is used to obtain a higher proportion of desired components that are initially dilute in a feed stream.

iii. Fractionation

   Fractionation is a separation process in which a certain quantity of a mixture (solid, liquid, solute or suspension) is divided up in a large number of smaller quantities (fractions) in which the changes according to a gradient.

The analysis of separation processes are divided into two fundamental categories:

i. Equilibrium-based processes
ii. Rate-based processes

For equilibrium-based processes, the degree of separation process in each stage is governed by a thermodynamic equilibrium relationship between the phases. Examples of separation processes in this category are:

i. Distillation
ii. Extraction and leaching

In distillation, the liquid is partially vaporized to create another phase, which is a vapor. The separation of the components depends on the relative vapor pressures of the substances. In distillation also, a different temperature at each stage alters the vapor phase equilibrium between typically binary mixtures.

The desire of a new equilibrium between the two phases at the temperature of each stage is the driving force for separation. The end result is the separation of two liquids with different boiling temperatures.

Extraction is a process where a species is removed from a liquid in which it is dissolved by means of another liquid for which it has higher affinity. While for leaching, a species is removed from a solid phase by means of another liquid for which it has a stronger affinity.

Rate-based processes are mainly about the limited of the processes by the rate of mass transfer of individual components from one phase into another under the influence of physical stimuli (such as concentration, temperature, pressure, external force). Under this category, there are a few types of processes:

i. Gas absorption
ii. Desorption or stripping
iii. Adsorption
iv. Ion exchange
v. Membrane separations

2.2 Extraction

Extraction is the process to remove one or more solutes from a liquid by transferring the solute into a second liquid phase, for which the solute has a higher affinity (Noble & Terry, 2004). This type of separation process depends on the differences in both solute solubility and density of the two phases.

In this process, there will be the advantages and disadvantages. One of the advantages is extraction can be performed at ambient temperature.

Thus, it is relatively energy efficient and can be applied to separations involving thermally unstable molecules.

2.3 Distillation

Distillation is one of the separation processes. Distillation is defined as a process in which a liquid or vapor mixture of two or more substances is separated into its component fractions of desired purity, by the application and removal of heat. Besides that, extraction processes can accommodate changes in flow rates and the solvent can be recovered and recycled for reuse. It offers greater flexibility in terms of operating conditions too, since the type, amount of solvent and operating temperature can be varied.

On the other hand, one of the disadvantages is, in this process, the solvent must be recovered for reuse (usually by distillation), and the combined operation is more complicated and often more expensive than ordinary distillation without extraction (McCabe, Smith & Harriott, 2001).

2.4 Ginger Oils Overview

The word Ginger is comes from the ancient Sanskrit word"*Singabera*" meaning shaped like a horn and the plant originates from India and being commonly found in South East Asia. The English botanists William Roscoe (1753-1831) give the plant name *Zingiber Officinale Roscoe* in an 1807 publication. Ginger oleoresin and ginger oil is derived from the fleshy part of the mesocarp of the herbs species. Ginger is a tropical herbaceous perennial with underground rhizomes from which stalks arise three feet tall. The leave is lancelote.